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SEVENTH EDITION

CONCRETE SIDEWALKS

With Chapters on
**CURBS,
GUTTERS,
FLOORS and
PAVEMENTS**

A Book of Practical information
— for the —
General Concrete Contractor

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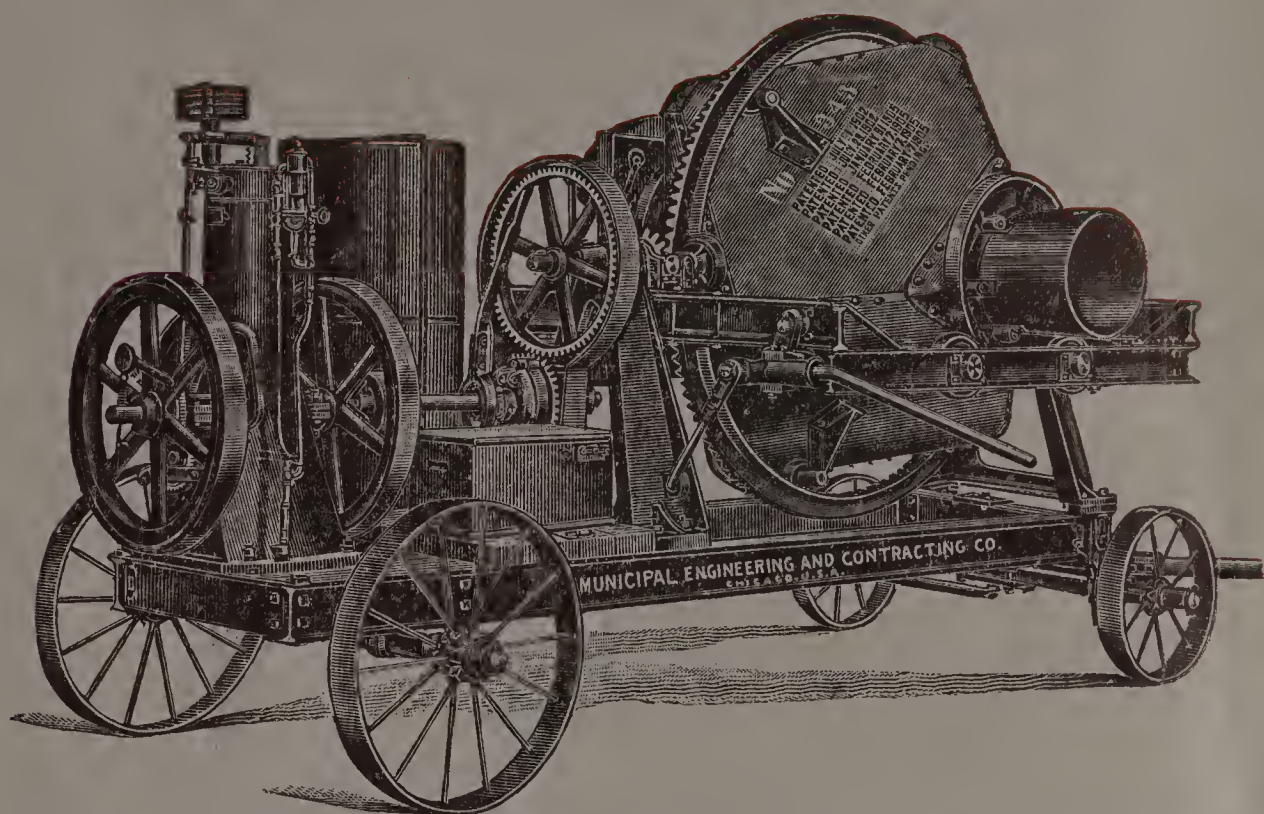
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Publishers of the Monthly Magazine

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DETROIT, MICHIGAN

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CONCRETE SIDEWALKS



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Sidewalk Work

Standard Specifications
Curb and Gutter,
Floors, Driveways, Pavements



Compiled by CONCRETE PUBLISHING CO.
DETROIT, MICHIGAN



Seventh Edition—Revised and Enlarged

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CONCRETE SIDEWALKS

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PREFACE

About three years ago, the Editors of CONCRETE put into short, concise form the best obtainable information dealing with the construction of concrete sidewalks. The first edition was printed in the fall of 1907 and rapidly exhausted. Reprinted editions were published in January, July and December of 1908, and an unusually large edition was issued in February, 1909. This also was exhausted and a still larger edition was prepared July 15, 1909. This, too, has been exhausted and the present edition is made necessary.

All the information that has proved of value in the six editions already issued has been retained and a considerable amount of new material is printed here. We take this opportunity to thank our many friends, who have made the preparation of the seventh edition a comparatively easy matter. Criticisms and suggestions are always welcome in connection with any book we publish.

Detroit, Michigan, June 10, 1911.

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CONCRETE SIDEWALK CONSTRUCTION.

Notwithstanding the extremely widespread use of concrete sidewalks and the many capable men engaged in building them or in directing their construction, poor walks are still occasionally seen. A few years ago a concrete sidewalk was a novelty; today, any other kind of sidewalk is so novel as to be almost unheard of. Cities, towns, villages and hamlets are provided with concrete walks, since continued experience has shown them to be the best adapted for footways. Wooden walks are out of the question, and, indeed, are prohibited in many cities. Brick walks, owing to the small size of the unit employed, seldom remain sightly very long; stone walks do not stand traffic so well as concrete. Concrete walks have secured an unassailable place and when properly laid are ideal.

Durability is, of course, essential in sidewalk construction, if the work is to be economical. Like almost every other good quality in concrete, durability depends entirely upon consideration of apparently small details. Specifications, the result of concerted reports from every part of the country, have been prepared for the construction of sidewalks,

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covering every step in the process. A typical set of specifications is the result of work done by the National Association of Cement Users. The most recent provisions for work of this kind are as follows:

Materials.

Cement shall meet the requirements of the Standard specifications for Portland Cement of the American Society for Testing Materials, adopted by this Association (January, 1906).

Aggregates.

Fine aggregates shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, passing when dry a screen having $\frac{1}{4}$ " diameter holes, shall preferably be of siliceous materials, clean, coarse, free from loam, vegetable or other deleterious matter, and not more than 3 per cent shall pass a sieve having 100 meshes per linear inch.

Mortars composed of 1 part Portland cement and 3 parts fine aggregate by weight when made into briquettes shall show a tensile strength of at least 70 per cent of the strength of 1 : 3 mortar of the same consistency made with the same cement and standard Ottawa sand.

Coarse aggregate shall consist of inert material, graded in size, such as crushed stone or gravel, which is retained on a screen

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having $\frac{1}{4}$ " diameter holes, shall be clean, hard, durable and free from all deleterious materials. Aggregates containing soft, flat or elongated particles shall be excluded.

Maximum size of the coarse aggregate shall be such that it will not separate from the mortar in laying and will not prevent the concrete fully filling all parts of the forms. The size of the coarse aggregate shall be such as to pass a $1\frac{1}{4}$ " ring.

Natural deposits of sand and gravel, usually being out of balance, shall be screened and remixed to agree with the proportions specified under Base. (Below.)

Where sub-base is specified, only clean, hard, suitable materials shall be used, not exceeding 4" in the largest dimension.

Water shall be clean, free from oil, acid, strong alkalies or vegetable matter.

Sub-Grade.*

Sub-grade shall have a slope toward the curb of not less than $\frac{1}{2}$ " per foot.

All soft or spongy places shall be removed, and all depressions filled with suitable material, which shall be thoroughly compacted by flooding and tamping in layers not exceeding 6" in thickness.

When a fill exceeding 1' in thickness is required to bring the walk to grade, it shall

(a) *Sub-grade shall not be less than 12" below the finished surface of the walk.

(b) Sub-grade shall not be less than 4" below the finished surface of the walk.

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be made in a manner suitable to the engineer. The top of all fills shall extend beyond the walk on each side at least 1', and the sides shall have a slope of at least $1\frac{1}{2}$ ".

When required, a suitable drainage system shall be installed and connected with sewers or other drains indicated by the engineer.

Sub-Base.*

On the sub-base and at least 2" beyond the inner and outer lines of the walk shall be spread a suitable material hereinbefore specified, which shall be rammed thoroughly to a surface at least 4" below the final grade of the walk. On fills, the sub-base shall extend the full width of the fill and the sides shall have the same slope as the sides of the fill.

While compacting the sub-base the material shall be kept thoroughly wet and shall be in that condition when the concrete is deposited.

*When a sub-base is required, omit paragraph (b) above. When sub-base is not required, omit paragraphs referring to it.

Forms.

Forms shall be free from warp and of sufficient strength to resist springing out of shape. All mortar and dirt shall be removed from forms that have been previously used.

Forms shall be well staked to the established lines and grades and their upper edges shall have sufficient rise from the curb to provide proper drainage, but shall not exceed

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$\frac{3}{8}$ " per foot except where such rise parallels the length of the walk.

In every 50 linear feet of walk at least one $\frac{1}{2}$ " joint shall be provided. Any means which will provide this will be accepted.

All forms shall be thoroughly wetted before any material is deposited against them.

Slabs.

Slabs or independently divided block, when not reinforced, shall not have an area of more than 36 square feet nor any dimension greater than 6'. Slabs of more than 36 square feet shall be reinforced with $\frac{1}{4}$ " steel rods, spaced not more than 9" apart, or with smaller rods or fabric of equal strength.

The thickness of slabs for residence districts shall not be less than 4" and for business districts not less than 5".

Base.

Concrete for the base shall be so proportioned that the cement shall overfill the voids in the fine aggregate by at least 5 per cent and the mortar shall overfill the voids in the coarse aggregate by at least 10 per cent. Proportions shall not exceed 1 part of cement to 8 parts fine and coarse aggregates.

When the voids are not determined the concrete shall be composed of 1 part cement, 3 parts fine aggregate and 5 parts coarse aggregate.

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Method of measuring the materials for the concrete, including water, shall be one which will insure separate uniform proportions at all times. A bag of cement (94 pounds) shall be considered to have a volume of 1 cubic foot.

Ingredients of the concrete shall be thoroughly mixed dry, sufficient water added to obtain the desired consistency, and the mixing continued until the materials are uniformly distributed and the mass is uniform in color and homogeneous.

When the conditions will permit, a machine mixer of a type which insures the uniform proportioning of the materials throughout the mass shall be used.

When it is necessary to mix by hand, mixing shall be done on a water-tight platform and the materials shall be turned until they are homogeneous in appearance and color.

The materials shall be mixed wet enough to produce a concrete of a consistency that will flush readily under light tamping, but which can be handled without causing a separation of the coarse aggregate from the mortar.

Retempering, that is, remixing with additional water, mortar or concrete that has been partially hardened, will not be permitted.

Forms shall be filled and the concrete struck off and tamped down sufficiently to receive a top of the required thickness. After

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the addition of water, the mixture shall be handled rapidly to the place of final deposit. Under no circumstances shall concrete be used that has partially hardened.

Concrete shall not be mixed or deposited when the temperature is below freezing unless special precautions are taken to avoid the use of materials containing frost, and to protect the work against frost until thoroughly hardened.

Workmen shall not be permitted to walk on freshly laid concrete, and where sand or dust collects on the base it shall be removed carefully before the wearing surface is applied.

Wearing Surface.

Wearing surface shall be mixed of 1 part cement and not more than 2 parts fine aggregate, with sufficient water to produce a consistency which will not require tamping, but which can be easily spread into position with a straight edge. Mortar for the wearing surface shall be mixed in a mortar box.

Wearing surface shall be spread on the base immediately after mixing, and in no case shall more than 50 minutes elapse between the time the concrete for the base is mixed and the wearing surface is placed.

Wearing surface of a walk in a residence district shall be at least $\frac{3}{4}$ " thick, and in a business district at least 1" thick.

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After the wearing surface has been worked to an approximately true plane the slab markings shall be made. If joints have been provided in the base during construction or have been cut in the base prior to spreading the wearing surface, the markings shall be made with a tool which will cut entirely through the surface and completely separate the wearing surface of adjacent slabs. If joints have not been provided in the base they must be made with a tool which will cut through to the sub-base and completely separate adjacent slabs.

Slabs shall be rounded on all surface edges to a radius of about $\frac{1}{2}$ ".

When required, the surface shall be troweled smooth. The application of neat cement to the surface in order to hasten the hardening is prohibited.

On grades exceeding 8 per cent the surface shall be roughened. This may be done by the use of a groover, toothed roller, brush, float or other suitable tool.

When coloring matter is required it shall be mixed dry with the sand and cement, which have been previously mixed dry, until the mixture is of a uniform color. The quantity and quality of the coloring shall be such as not to impair the strength of the wearing surface.

When completed, the walk shall be kept moist and protected from traffic and the elements for at least three days.

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Single Coat Work.

With the following exceptions the specifications covering two-coat work will apply to single coat work:

Proportions shall not exceed 1 part cement, 2 parts fine aggregate and 3 parts coarse aggregate.

Materials shall be mixed wet enough to produce concrete of a consistency which will not permit tamping, but which can be handled without causing a separation of the coarse aggregate from the mortar.

Forms shall be filled, the concrete struck off and the coarse particles forced with a suitable tool to a depth below the surface which will permit finishing the walk as specified for two-coat work.

CURB AND GUTTER CONSTRUCTION

Closely connected with concrete sidewalk construction is the matter of providing concrete curb and gutter. These have been adopted by a number of municipalities, and are in many ways to be preferred to the older stone curbs. The combination curb and gutter, with either plain or reinforced curb, is neat, durable and comparatively inexpensive.

For curb and gutter construction, the following specifications were recently adopted by the National Association of Cement Users:

Materials.

Cement shall meet the requirements of the Standard Specifications for Portland cement of the American Society for Testing Materials, adopted by this Association.

Fine aggregates shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, passing when dry a screen having $\frac{1}{4}$ " diameter holes, shall be preferably of siliceous materials, clean, coarse, free from loam, vegetable or other deleterious matter, and not more than 3 per cent shall pass a sieve having 100 meshes per linear inch.

Mortars composed of one part Portland cement and 3 parts fine aggregate by weight

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when made into briquettes shall show a tensile strength of at least 70 per cent of the strength of a 1:3 mortar of the same consistency, made with the same cement and standard Ottawa sand.

Coarse aggregates shall consist of inert materials graded in size, such as crushed stone or gravel, which are retained on a screen having $\frac{1}{4}$ " diameter holes, shall be clean, hard, durable and free from all deleterious matters. Aggregate containing soft, flat or elongated particles shall be excluded.

The maximum size of the coarse aggregates shall be such that they will not separate from the mortar in laying and will not prevent the concrete from filling all parts of the forms. The size of the coarse aggregate shall be such as to pass a $1\frac{1}{4}$ " ring.

Natural deposits of sand and gravel usually being out of balance, shall be screened and remixed to agree with the proportions specified under Base. (See Concrete Roadways and Street Specifications.)

Only clean, hard, suitable material shall be used, not exceeding 4" in the largest dimension.

Water shall be clean, free from oil, acid, strong alkalies or vegetable matter.

The expansion joint filler shall be suitable elastic waterproof compound that will not become soft and run out in hot weather or become hard and brittle and chip out in cold weather.

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Sub-Grade.

When a sub-base is required the sub-grade shall be not less than 12" below the finished surface of the gutter.

All soft or spongy places shall be removed and all depressions filled with suitable filling material, which shall be thoroughly compacted by flooding and tamping in layers not exceeding 6" in thickness.

When a fill exceeding 1' in thickness is required to bring the work to grade it shall be made in a manner satisfactory to the engineer.

When required, a suitable drainage system shall be installed and connected with sewers or other drains indicated by the engineer.

Sub-Base.

A sub-base shall be provided if required by the engineer, composed of cinders or other suitable material hereinbefore specified, which shall be rammed thoroughly to a surface at least 6" below the finished surface of the gutter.

While compacting the sub-base the material shall be kept thoroughly wet and shall be in that condition when the concrete is deposited.

Forms.

Forms shall be free from warp, and of sufficient strength to resist springing out of shape. All mortar and dirt shall be removed

CURB AND GUTTER

from forms that have been previously used.

Forms shall be well staked or otherwise held to the established line and grade, and their upper surfaces shall conform with finished surfaces of the curb and the gutter, respectively.

At least once in every 150', $\frac{1}{2}$ " expansion joints shall be provided.

All forms shall be thoroughly wetted before any material is deposited against them.

Completed curb must be at least 24" deep, not less than 12" thick at the base, not less than 6" thick at the top, and the street side shall have a batter of 1 to 4.

For combination curb and gutter, the curb must be at least 12" deep at the back and the depth of the face not less than 6".

Breadth of the gutter shall not be less than 16" nor more than 24".

Construction.

Curb and gutter shall be divided into sections not less than 5' nor more than 8' long, by some method which will insure the complete separation of the sections by a joint not less than $\frac{1}{8}$ " nor more than $\frac{1}{4}$ " wide.

Concrete.

The concrete for the curb and gutter shall be so proportioned that the cement shall overfill the voids in the fine aggregate by at least 5 per cent., and the mortar shall overfill

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the voids in the coarse aggregate by at least 10 per cent. The proportions shall not exceed 1 part cement to 8 parts fine and coarse aggregates. When the voids are not determined, the concrete shall be composed of 1 part cement, 3 parts fine aggregate and 5 parts coarse aggregate.

The method of measuring the materials for the concrete, including water, shall be one which will insure separate uniform proportioning at all times. A bag of cement (94 pounds) shall be considered to have a volume of 1 cubic foot.

Ingredients of the concrete shall be thoroughly mixed dry, sufficient water added to obtain the desired consistency, and the mixing continued until the materials are uniformly distributed and the mass is uniform in color and homogenous.

When conditions will permit, a machine mixer of a type which insures the uniform proportioning of the materials throughout the mass shall be used.

When it is necessary to mix by hand, mixing shall be done on a water-tight platform and the materials shall be turned until they are homogenous in appearance and color.

Materials shall be mixed wet enough to produce a concrete of such a consistency that it will flush readily under light tamping and which can be handled without causing a separation of the coarse aggregate from the mortar.

CURB AND GUTTER

Retempering, that is, mixing with additional water, mortar or concrete that has partially hardened will not be permitted.

A layer of concrete shall be deposited to the top of the gutter form and tamped, the width of the gutter, to a surface all points of which shall be at least the thickness of the wearing surface below the finished surface of the gutter. Concrete placed for the curb shall be tamped and the remainder of the concrete placed and tamped to permit of the application of the required wearing surface to the face and top of the curb. After the addition of water the mixture shall be handled rapidly to the place of final deposit. Under no circumstances shall concrete be used that has partially hardened.

Concrete shall not be mixed or deposited when the temperature is below freezing unless special precautions are taken to avoid the use of materials containing frost until thoroughly hardened.

Workmen shall not be permitted to walk on freshly laid concrete, and where sand or dust collects on the concrete it shall be carefully removed before the wearing surface is applied.

Wearing Surface.

Wearing surface shall be mixed 1 part cement and not more than 2 parts fine aggregate, with sufficient water to produce a consistency which will not require tamping, but

CURB AND GUTTER

which can be easily spread into position. Mortar for the wearing surface shall be mixed in a mortar box.

Wearing surface shall be placed immediately after mixing, and in no case shall more than 50 minutes elapse between the time the concrete is mixed and the time the wearing surface is placed.

Wearing surface on the gutter and on the top and face of the curb shall be at least $\frac{3}{4}$ " thick.

Surface and edges of the curb and gutter and joints between sections shall be finished in a workmanlike manner.

Edge of the curb on the street side and the intersection of the curb and gutter shall be rounded to radius of about $1\frac{1}{2}$ ", all other edges to have a radius of about $\frac{1}{2}$ ".

When required, the surface shall be troweled smooth. The application of neat cement to the surface in order to hasten hardening is prohibited.

When coloring matter is required it shall be mixed dry with the sand and cement which have been mixed dry, until the mixture is of a uniform color. Quantity and quality of the coloring shall be such as not to impair the strength of the wearing surface.

Protection.

When completed, the curb and gutter shall be kept moist and protected from traffic for at least a week.

CONCRETE ROADWAYS AND STREETS.

Concrete as a material for surfacing roads and streets is being used with increasing frequency. Its cheapness and durability commend it to the taxpayer and the comparative ease and rapidity with which concrete pavements can be laid are additional factors in its success. The following Standard Specifications for concrete road and street pavements have been adopted by the National Association of Cement Users:

Materials.

Cement shall meet the requirements of the Standard Specifications for Portland cement of the American Society for Testing Materials, adopted by this Association.

Fine aggregates shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, passing when dry a screen having $\frac{1}{4}$ " diameter holes, shall be preferably of siliceous materials, clean, coarse, free from loam, vegetable or other deleterious matter, and not more than 3 per cent shall pass a sieve having 100 meshes per linear inch.

ROADWAYS AND STREETS

Mortars composed of 1 part Portland cement and 3 parts fine aggregate by weight when made into briquettes shall show a tensile strength of at least 70 per cent of the strength of a 1:3 mortar of the same consistency, made with the same cement and standard Ottawa sand.

Coarse aggregates shall consist of inert material, graded in size, such as crushed stone or gravel, which is retained on a screen having $\frac{1}{4}$ " diameter holes, shall be clean, hard, durable and free from all deleterious matter. Aggregates containing soft, flat or elongated particles shall be excluded.

The maximum size of the coarse aggregate shall be such that it will not separate from the mortar in laying and the size of the coarse aggregate shall be such as to pass a $1\frac{1}{2}$ " ring.

Natural deposits of sand and gravel usually being out of balance, shall be screened and remixed to agree with the proportions specified under Base.

Only clean, hard, suitable material shall be used, not exceeding 4" in the largest dimension.

Water shall be clean, free from oil, acid, strong alkalies or vegetable matter.

Expansion joint filler shall be a suitable elastic, waterproof compound that will not become soft and run out in hot weather or become hard and brittle and chip out in cold weather.

ROADWAYS AND STREETS

Sub-Grade.

Sub-grade shall have a rise at the center of not more than one one-hundredth ($1/100$) of the width of the pavement.

(a)* Sub-grade shall not be less than $13\frac{1}{2}$ " below the finished surface of the pavement.

(b) Sub-grade shall not be less than $7\frac{1}{2}$ " below the finished surface of the pavement.

All soft or spongy places shall be removed, and all depressions filled with a suitable material, which shall be thoroughly compacted in layers not exceeding 6" in thickness.

When a fill exceeding 1' in thickness is required to bring the pavement to grade, it shall be made in a manner satisfactory to the engineer.

When required, a suitable drainage system shall be installed and connected with sewers or other drains indicated by the engineer.

Sub-Base.*

On the sub-grade shall be spread a suitable material hereinbefore specified which shall be rolled or rammed thoroughly to a surface at least $7\frac{1}{2}$ " below the finished surface of the pavement.

While compacting the sub-base, the material shall be kept thoroughly wet and shall be in that condition when the concrete is deposited.

*When a sub-base is required eliminate paragraph b.
When a sub-base is not required eliminate paragraph a.
Unless a is eliminated b is void.

ROADWAYS AND STREETS

Forms.

Forms shall be free from warp and of sufficient strength to resist springing out of shape. All mortar and dirt shall be removed from forms that have been previously used.

Forms shall be well staked to the established lines and grades.

All forms shall be thoroughly wetted before any material is deposited against them.

Expansion Joints.

Expansion joints $\frac{1}{2}$ " wide shall be placed at least every 50' and between the curb or edge of the gutter and the pavement.

Base.

Concrete for the base shall be so proportioned that the cement shall overfill the voids at least 5 per cent and the mortar shall overfill the voids in the coarser aggregate by at least 10 per cent. Proportions shall not exceed 1 part of cement to 8 parts fine and coarse aggregates.

When the voids are determined, concrete shall have the proportions of 1 part cement, 3 parts fine aggregate and 5 parts coarse aggregate.

The method of measuring materials for the concrete, including water, shall be one that will insure separate uniform proportions at all times. A bag of cement (94

ROADWAYS AND STREETS

pounds) shall be considered to have a volume of 1 cubic foot.

Ingredients of the concrete shall be thoroughly mixed dry, sufficient water added to obtain the desired consistency, and the mixing continued until the materials are uniformly distributed and the mass is uniform in color and homogeneous.

When conditions will permit, a machine mixer of a type which insures the uniform proportioning of the materials throughout the mass shall be used.

When it is necessary to mix by hand, mixing shall be done on a water-tight platform and the materials shall be turned until they are homogeneous in appearance and color.

Materials shall be mixed wet enough to produce concrete of a consistency that will flush readily under light tamping, but which can be handled without causing a separation of the coarse aggregate from the mortar and which will not creep towards the curb nor sag out of place when deposited and lightly tamped.

Retempering, that is, remixing with additional water, mortar or concrete that has partially hardened, will not be permitted.

Concrete shall be deposited in strips extending across the whole area to be paved. After the addition of water the mixture shall be handled rapidly to the place of final deposit. Under no circumstances shall concrete be used that has partly hardened.

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Concrete shall not be mixed or deposited when the temperature is below freezing unless special precautions are taken to avoid the use of materials containing frost, and to protect the work against frost until thoroughly hardened.

Workmen shall not be permitted to walk on freshly laid concrete, and where sand and dust collect on the base they shall be removed carefully before the wearing surface is applied.

Wearing Surface.

Wearing surface shall be mixed of 1 part cement and not more than $1\frac{1}{2}$ parts fine aggregate, with sufficient water to produce a consistency which will not require tamping, but which can be easily spread into position with a straight edge.

Wearing surface shall be spread on the base immediately after mixing and in no case shall more than 50 minutes elapse between the time that the concrete for the base is mixed and the time the wearing course is floated.

Wearing surface of the pavement in a residence district shall be at least $1\frac{1}{2}$ " thick, and in a business district at least 2" thick.

Wearing surface shall be finished with a wood float, and before it has completely hardened it shall be roughened by brushing with a stiff vegetable fiber brush or broom.

ROADWAYS AND STREETS

Edges of all expansion joints shall be rounded to a radius of about $\frac{1}{2}$ ".

Where coloring matter is required it shall be mixed dry with the sand and cement, which have been previously mixed dry, until the mixture is of a uniform color. The quantity and quality of the coloring shall be such as not to impair the strength of the wearing surface.

Protection.

When complete the pavement shall be kept well sprinkled with water for a period of at least three days and shall not be thrown open to traffic until the engineer so directs.

CONCRETE PAVEMENT

TYPES OF CONCRETE PAVEMENT IN GENERAL USE.

The ideal pavement has been defined as one that is durable, clean, sanitary, noiseless, easy on traffic, low in price and free from excessive maintenance charges. Under proper conditions, concrete paving approaches very closely these specifications. In proper concrete pavements, the surface is easily cleaned and certainly sanitary. It is less noisy than stone, brick or asphalt (in cold weather), and little more noisy than block, while it is of course infinitely longer-lived. Teamsters' unions have generally testified that concrete is not hard on the hoofs of horses. Its resistance to automobile traffic is good, and this is an important point nowadays. The surface is readily roughened to a point that insures freedom from slipping.

Concrete pavement is by no means an experiment. Those at Bellefontaine, Ohio, have been down seventeen years; Richmond, Ind., has been using concrete pavements for thirteen. Pavements of these ages in those two towns are in first-class condition today. They have stood the traffic as well as any other form of pavement, and better than most other forms. City engineers in Philadelphia, Pa., Troy, N. Y., Worcester and

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Lowell, Mass., Davenport, Ia., Fond du Lac, Wis., Washington, D. C., New Orleans, La., Denver, Col., Omaha, Neb., and Toronto, Ont., speak highly of concrete, after observation of its advantages as a pavement, extending over considerable periods. The traffic of the largest cities is handled with as good results as is that of the smaller ones.

Specifications for the Bellefontaine, Ohio, pavement, probably the oldest successful pavement of its kind in this country, were about as follows: The whole pavement is 6" thick, with a concrete base 4" thick and a top or wearing surface 2" in thickness. The base is 1:4 gravel concrete and the top surface 1:1 screened black sand. Concrete was mixed in careful proportions, using the continuous type of concrete mixer. Cement and aggregate were first measured and mixed and then supplied to the mixer proper. Starting at either curb, concrete was laid in strips 5' concrete pavement in the center, from 10' to wide, extending the width of the street, and this strip was afterwards blocked off into slabs 5' square, care being had to insure complete separation of one block from another. No expansion joints, in the ordinary sense of the term, were used, the block divisions taking their place with entire satisfaction. Footing for horses was secured by dividing the slabs into blocks about 4" square, using a V-shaped tool, about $\frac{1}{2}$ " wide and $\frac{1}{2}$ " deep on the cut.

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. In Mason City, Ia., the pavement consists of 7" of concrete—a base 5" thick, made of 1:2:5 concrete. Screened stone, from $\frac{1}{2}$ " to $1\frac{1}{2}$ " in diameter, was used for the coarsest aggregate. The top surface was of course 2" thick. Corrugations were used in the first pavement laid, but the engineer in charge has decided that in future the pavement will be simply roughened with a paver's broom, to give the requisite foot-hold for horses. Expansion joints are provided, 1" wide, along either curb, and transversely across the pavement every 25'. Between these joints, or 12' 6" from the transverse expansion joint, there are provided additional joints $\frac{1}{8}$ " wide. A cut down the center of the pavement, parallel to the curb, is also provided. The effect is to block the pavement off into slabs about 10' or 12' 6" square, depending a little on the width of the pavement. Expansion joints are filled with asphaltic material and their edges treated with a rounding tool before the concrete has hardened. The absence of sharp edges to chip off has resulted satisfactorily.

This pavement cost \$1.25 per square yard, including a 7" excavation. Prices of material were as follows: Crushed rock, on the job, \$1.35; sand, on the job, 85c per cubic yard; cement, on the job, \$1.20 per bbl. Labor could be obtained at from \$2.00 to \$2.50 per day. Unquestionably these prices are

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lower than would obtain in some other localities.

In general, pavements are laid with an average thickness of 7"—about 5" for the foundation course and about 2" for the top or wearing surface. Foundation course is mixed about $1:2\frac{1}{2}:4\frac{1}{2}$, and the wearing surface $1:1\frac{1}{2}$. Proper allowance for expansion is absolutely essential.

Materials must be selected with great care. Portland cement should be of standard quality and subjected to all the tests. For aggregate, the hardest stone, like flint, granite or trap-rock, should be utilized.

General Paving Specifications.

Experience suggests the following general specifications:

The sub-grade shall be the exact shape of the finished road, heavily rolled with a 10-ton roller, and made absolutely solid.

In loose, porous soils, no provision for drainage is necessary. In heavy or wet soils, a layer of cinders or agricultural tile at either side of the roadway, in a cinder-covered trench, should be provided.

Sand for the wearing surface should be washed and screened, and should consist chiefly of siliceous material.

The hardest stones should be used for the coarse aggregate. Crusher-run stone should not be utilized, unless all fine material is rejected.

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Water should be fresh and free from any impurity that will injure concrete.

Portland cement that is up to the standard specifications of the American Society for Testing Materials should be employed.

Bottom or foundation course should be 5" in thickness after complete tamping or rolling. It should consist of 1:2½:5 concrete.

Wearing surface should be placed immediately on the foundation course, before the latter has had time to set. It should be about 1½" in thickness, composed of 1 part Portland cement and 2 parts selected torpedo sand, or 1 of cement, 1 of torpedo sand and 1 of granite screenings.

Base should not be mixed too wet. As soon as 25' of base are completed, the wearing surface should be put on, using a wet mixture, similar to that used for concrete sidewalks.

Work is facilitated by the use of templates, drawn to the exact shape of the finished paving.

Corrugations are unnecessary on streets with a grade of less than 3 per cent.

Roughness may be secured by brooming the pavement as soon as the wearing surface begins to stiffen.

It is unwise to roughen the surface of the pavement immediately adjacent to the curb, for a distance of say 2', as any roughness here will result in obstructing the flow of water to the drains.

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Expansion joints should be definite and thoroughly made, cutting through the top coat and the bottom coat of the pavement, down to the excavation. They ought to be at least 1" wide next to the curbs and transverse joints across the pavement ought to be $\frac{1}{2}$ " wide. Rounding off the upper edges of all joints is an excellent protection against chipping and spalling. Contraction joints, made by inserting $\frac{1}{8}$ " steel plates at points equidistant from the expansion joints, should be made, dividing the complete pavements into blocks or slabs about 10' or 12' square.

All joints should be filled with an asphaltic filler of an approved type.

Pavements, when completed, should be kept dampened for seven days at least, and kept free from traffic during that time.

Concrete in Highway Construction.

As distinguished from city pavements, suburban and rural roadways present many interesting problems to the road-maker. Many of these problems are conveniently solved when concrete is used. A number of advances have recently been made in the use of concrete for highways, with gratifying success.

For example, several roads leading out of Detroit, Michigan, are constructed with a concrete pavement in the center, from 10' to 18' wide. On either side of this roadway are laid shoulders of gravel or macadam, wide enough to take up the balance of the road-

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way, whatever its width may be, say 24' to 30'. One highway of this general type was laid in 1909 and proved so satisfactory that in 1910 about fifteen miles of similar construction were put down. Cost has naturally varied, according to local conditions, but has averaged in the neighborhood of \$1.35 per square yard of concrete.

At Ann Arbor, Michigan, an interesting method for preventing spalling and chipping at the edges of expansion joints has been devised. It consists, briefly, in coating the surface of the finished roadway, which is laid under the general specifications for concrete roadways, with a surface painting of tar, covered with a thin layer of fine gravel or coarse sand. The tar is applied after the concrete has set and when it is quite dry, and either hot coal-tar or distilled coal-tar is used. Expansion joints are filled with a mixture of pitch or of tar and sand, and care is taken that the joints are filled perfectly flush with the surface of the pavement. Before the surface coating of tar has hardened a uniform, thin layer of fine gravel, or coarse sand, is spread.

In applying the tar, a steel tank, holding about 450 gallons, is used, with a fire-box below for heating the tar and keeping it liquid. It is fed to the surface of the street through a 2" gas-pipe. As soon as the tar-wagon has passed, a rotary sweeper follows, distributing the tar uniformly over the surface of the

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roadway. The sand is screened and then spread by a wagon carrying a triangular box. Near the bottom of the box is a shaft geared to the hubs of the wagon wheels. As this shaft revolves, the sand is fed to a screen and from the latter distributed in an even layer over the surface of the roadway.

The finished pavements resemble sheet asphalt. Glare and the reflection of heat are both overcome by the use of this method of surfacing. All cracks, joints and depressions are filled with the sand-tar mixture and disappear from sight. With the cushion on top, the expansion joints do not chip at the edges. Traffic is not noisy on pavement treated in this way and the waterproof coating assists the pavement in rapidly shedding rain water. In the possible event of cracks appearing in the body of the pavement, they are simply swept with the tar and sand mixture, when they are filled, and crumbling is prevented. In brief, it may be said that the treatment overcomes the objections that have been urged against concrete as a highway material.

Cost of this treatment is reported to be about 2 cents per square yard, and since one treatment lasts for two years, it is extremely cheap.

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HOW TO MAKE GOOD CONCRETE.

All concrete work, in order to be worthy of the name, must conform to certain definite methods of selecting and combining material. It is safe to say that errors of ignorance, carelessness or design, in selecting proper materials and in combining them have been responsible for every cubic inch of poor concrete that has ever been produced. Using intelligent care throughout every step of selecting materials, combining them, mixing them, depositing them and curing them is the only possible way in which to secure good concrete. It is believed that the following suggestions will be of value. They embody the recommendations of a number of practical, successful workers in concrete, men who recognize the value of the material and who are desirous of seeing nothing but the best concrete made.

There are four absolute requisites for the manufacture of good concrete for any purpose—Portland cement, sand, gravel (or crushed stone) and water. Unless all of the ingredients are selected with a knowledge of what they ought to be, failure is a possibility.

For the successful manufacture of concrete for sidewalks, or for any other purpose,

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it is obvious that the selection of the cement is of first importance. Thanks to the work done by the American Society for Testing Materials, the N. A. C. U., the government laboratory for testing materials and the engineering bodies, a wholly definite standard for Portland cement has been formulated. Practically every Portland cement marketed in any considerable quantity today is made to conform with the accepted standards of the American Society for Testing Materials, and the concrete man is safe in using any one of them, providing that conditions of storage have been proper. Sidewalks are naturally subjected to constant exposure to the sun, wind and rain, and the best material is none too good for them.

Portland cement must be "sound." That is, it must be composed of the right proportions of silica, lime and alumina and the mass must be properly burned. When curing concrete begins to break out into bubbles or blisters and the mass later begins to disintegrate, it is too late to do very much but tear out the work and lay new, with resulting expense and loss. Free lime in cement is a pretty certain cause of this particular form of trouble, but to the casual observer free lime does not make its presence known at once. The writer has seen samples of cement which, when they were breathed upon, gave off very strongly the characteristic odor of lime. It is, of course, unwise to make use of

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this class of cement, but there are also cements that under most rough and ready tests appear to be of fairly good quality. Free lime, in the process of manufacturing cement, is often protected from the action of moisture by the clinker that is formed in the burning process and it is only when it is impossible to remedy the difficulty, that is, after the cement has been used in concrete, that the lime is affected by moisture and trouble begins. It will be found an excellent precaution to confine one's dealings to reputable firms of cement manufacturers, those with reputations to sustain or to make, and that are turning out their product in sufficient quantity to insure its being well aged, and not going directly from the kilns to the customer. Under the American system of Portland cement manufacture, the cement is ordinarily well aerated before it is even barreled, but a period of storage, under proper conditions, never harmed any cement, and it improves most of it. In fact, one of the United States government's requirements is that the cement used in government construction shall pass tests which show that it is thoroughly aerated.

Grinding is an important branch of cement manufacture and the best specifications are definite on this point. The American Society for Testing Materials, for example, requires in its specifications that cement, on being sifted, shall leave a residue of not more than

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8 per cent on the No. 100 sieve. The Society has determined upon this specification only after exhaustive tests and all of the specification provisions have been demonstrated to be well within the bounds set by experience and practicability. It is safe to say that any cement which comes up to these specifications is satisfactory to use and any manufacturer or dealer is ordinarily willing to demonstrate that his goods are up to the mark.

The time of setting is also an important matter. Cement that does not set too quickly should be chosen. A "flash" set should be enough to cause the user to regard the cement under inspection with grave doubt. Those brands which attain their final set in from four to nine hours are to be preferred to those that set more quickly. Too rapid setting is often a sign of argillaceous matter, or clayey material.

Good cement, however, hardens promptly. In other words, its final set should be achieved within a comparatively short space of time. Once the final set is accomplished, the process of hardening begins and continues over a long space of time. The best cement, in general, is one that is comparatively slow-setting and quick-hardening.

In undertaking concrete work of any kind, the character of the Portland cement to be used is of the very first importance. Get a product that is sound, seasoned, finely ground, slow-setting and quick-hardening.

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Have the man who supplies you satisfy you on these points, first of all. Have a clear understanding with him that if the cement does not come up to that mark, it will be rejected from your work. If the cement fulfills these requirements you will have taken a long step toward preventing trouble of various kinds.

Selecting the Sand.

Hardness is one of the first considerations in the selection of sand for concrete work. Dirty sand can be washed and poorly graded sand can be rectified by the addition or subtraction of the proper percentages of particles of the right size. But sand that is soft is worse than useless. Any elements like clay, loam or silt are extremely detrimental, for two reasons. First, they are soft and soluble and readily wash out of the concrete, leaving voids in their places. Second, if they are finely divided, they coat the particles of sand, preventing the cement from bonding with them, thereby defeating the most important function of the cement. Sand, ideal as to hardness and size of grains, is poor if it is dirty. To demonstrate the truth of this statement it is only necessary to make one batch of concrete with dirty sand and another with the same sand after washing. The difference in quality is apparent to the eye and under test the clean concrete shows great superiority.

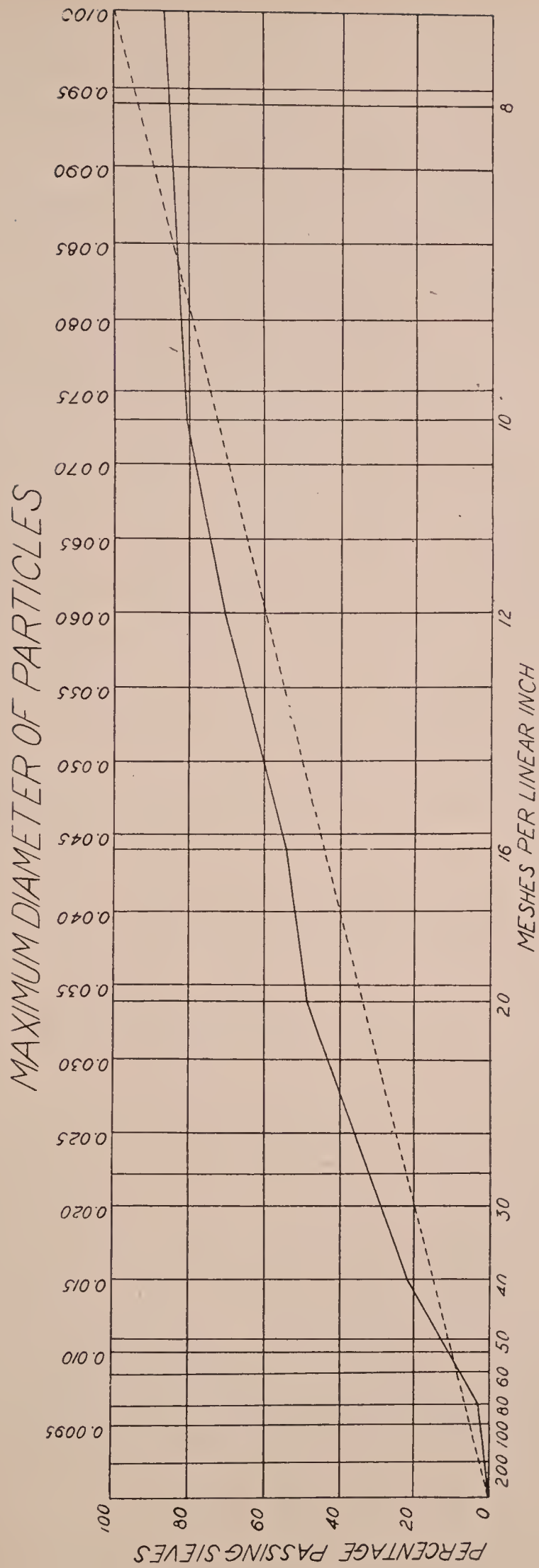
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Where it is possible to obtain it, sand with sharp grains is to be preferred to material with rounded elements. A simple test for determining both the cleanness of sand and the character of its grains is to rub a sample sharply between the hands. The peculiar "gritty" feel of the sharp sand and the absence of stain on the palms are two points in favor of using the sand. Another good plan is to throw a handful of the sand into a pail of water and let it stand for an hour or more. Dirt will be exposed by this method. If the sand is stirred up from time to time while it is under observation any mud or silt present will at last form a thin, slimy film on the upper surface of the mass. Particles of vegetable matter will rise to the surface of the water and clay and loam elements present will stain the water. If the sand is dirty, or if it shows the least sign of general softening or disintegration, it should be absolutely rejected.

Sand may be hard and clean and still entirely unfit for use in concrete work of any kind. Proper grading in the size of the particles is an essential, not only for the sake of good concrete, but for the sake of legitimate economy as well. Under modern designation, sand is considered as material with its grains having a maximum diameter of $\frac{1}{8}$ ". Gravel runs in size from $\frac{1}{8}$ " to 1", and larger sizes of aggregate come under the general head of crushed stone.

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In order to determine with exactness the availability of sand, it should be subjected to the following analysis: A well mixed sample, of known weight, dry, should be washed carefully, dried and weighed again. The loss of weight in washing determines the percentage of soluble material present. The sample should then be screened through a set of sieves, ranging from the No. 8—that is, with eight meshes to the linear inch, or 64 to the square inch—to the No. 200—with 200 meshes to the linear inch, or 40,000 to the square inch. The percentages passing each sieve are plotted in a curve, using a parallelogram in which the vertical line represents the meshes per linear inch (with maximum diameter of particles passing) and the horizontal line represents percentages which pass. Comparisons of this curve with the normal curve show the exact percentages of material of a given size that must be added to or subtracted from the sand in order to make it conform most closely with the ideal, voidless sand. In the accompanying illustration, for example, is shown the curve drawn from an analysis of sand submitted to CONCRETE from a Michigan pit. Note that the size of particles passing the sieves is shown at the top of the figure, percentages passing are shown at the left, and the number of meshes per linear inch in the sieves is shown at the bottom. Thus, about 2 per cent passed the 200-mesh sieve; about $2\frac{1}{2}$ per cent



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the 100-mesh sieve; about 4 per cent the 80-mesh sieve; about 9 per cent the 60-mesh sieve; about 14 per cent the 50-mesh sieve; about 23 per cent the 40-mesh sieve; about 34 per cent the 30-mesh sieve; about 50 per cent the 20-mesh sieve; about 56 per cent the 16-mesh sieve; about 70 per cent the 12-mesh sieve; about 81 per cent the 10-mesh sieve, and about 85 per cent the 8-mesh sieve.

If the sand under examination were ideal, that is, without any voids whatever, the percentages passing the sieves of given mesh would be represented by the height on the vertical lines to which the dotted line rises. In other words, there would be about 10 per cent through the 60-mesh sieve, 24 through the 30-mesh sieve, 44 through the 16-mesh sieve; and so on. It is therefore a simple matter, by comparing the percentages that would pass in the ideal sand (represented by the dotted line) with those actually passing in the sample under examination, to determine what percentage of material of a given size ought to be added to or subtracted from the sample in order to eliminate voids. In the chart in question, there would have to be **added** about 1 per cent of the material that passes a 200-mesh sieve; 2 per cent of the material that passes a 100-mesh sieve; 4 per cent of the material that passes an 80-mesh sieve. The amounts passing the 60-mesh sieve coincide with almost perfect exactness.

There would have to be **subtracted** about

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2 per cent of the material passing the 50-mesh sieve; about 5 per cent of the material passing a 30-mesh sieve; about 18 per cent of the material passing a 20-mesh sieve; and so on. When the sample's curve falls **below** the ideal curve, it is obvious that sufficient material of such a diameter as will pass the sieve of the same mesh must be **added** to the sample, in order to make the curves coincide. When the sample's curve falls **above** the ideal curve, material must be **subtracted**.

The computation in the present case may seem somewhat long and tedious, but in a full-size blue print the amounts are very readily determined. In the sample of sand under discussion, there are no striking differences between the sample curve and the ideal curve; and practically no rectification of the aggregates, by addition or subtraction, is required. In many samples, however, the sample's curve goes very much above or below the ideal, and since the chart shows definitely how far it goes either way, and at the same time shows a definite percentage, in terms of particles of a definite diameter, it is a simple matter to note the difference and make the proper addition or subtraction. Suppose, for instance, that in a sample of sand run through the sieves, the percentage of particles passing the 16-mesh sieve was as high as 80. This would be rather an extraordinary case, but is suggested merely by way of illustration. The curve on the chart would

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show a high point or peak, with its top at 80 per cent. The percentage for the ideal curve is only about 42, or 38 less than that shown by the sample suggested. If 38 per cent of the particles of the samples passing the 16-mesh sieve were subtracted from the sample as a whole, the sample would obviously be greatly improved.

This matter has been gone into at considerable length in the belief that it is comparatively little understood and because it is known to be one of the utmost importance.

In the place of sand, where this material is not readily obtainable, it is profitable to use crusher screenings. The chief objection to their use lies in the possible presence of a comparatively high percentage of crusher dust or "flour." Any considerable amount of this element certainly weakens the concrete. A sieve analysis of the crusher screenings will at once determine their fitness for use. What has been said about cleanliness and hardness of sand applies with equal force to crusher screenings and, indeed, all other material for concrete. Crushings from the hardest stones, like granite or trap, are the best to use.

Gravel.

All that has been said of sand in general is perfectly applicable to gravel used in concrete work. A sieve analysis, using stone screens with large mesh, is of great service

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in a definite determination of its fitness for use.

Cinders.

In sidewalk concrete the use of cinders as a part of the mixture is not advisable where any other aggregate is available. Under proper specifications cinders add to the fire-proof qualities of floors and arches, but in sidewalks they are of no special value, and if not the right kind they are very likely to be the source of trouble. Where there is lime in the ash, or sulphur, as there is almost invariably, the surface of the walk will become pitted. Where it is necessary to make use of cinders get them free from unburned coal, and use about 25 per cent extra of sand to fill the higher percentage of voids.

Crushed Stone.

What has been said of gravel applies with equal force to the selection of crushed stone. Since the strength of concrete depends on the hardness of the materials of which it is composed, it is obvious that the strongest material makes the strongest concrete.

The general theory of making strong concrete is based upon having the material of sizes so graded that the smaller particles fill the spaces between the larger ones. Under ideal conditions there would be no spaces at all. The particles of sand would fill the spaces between the particles of gravel or

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crushed stone and the cement in turn would fill the spaces between the particles of sand. The best concrete results when every separate grain of sand is covered with cement, so as to make a mortar, which in turn covers each particle of the aggregate and binds the whole mass strongly together.

Water.

Water for use in the manufacture of good concrete must be clean and pure, in that it is free from alkali, sulphur, iron or discoloration. The water serves a most important purpose in setting up the chemical action of crystallization in the cement, without which it does not harden. The presence of impurities of any kind in the water results in discoloration of the sidewalk, while dirt, dust and so on may have the effect of forming a thin film between the lower and the upper coat, with the result that they will not bond together. A soft water, clean and clear, used not too cold, will give the best results.

Mixing.

Cement sidewalks are ordinarily made in two sections, a bottom and an upper coat. Where gravel is to be used in the lower coat, the proportion should be 1 part of Portland cement to 4 parts of clean, hard gravel, with graded sand enough to fill the voids in the gravel. An average rule for the amount of

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sand would be to use one-fourth as much of this material as gravel, so that the bottom coat is made up of 1 part of cement to 5 of aggregate.

If crushed or broken stone is used instead of gravel, it is best to use 1 part of Portland cement, 2 parts of clean, sharp sand and 4 parts of broken stone. The larger quantity of sand is used because of the larger number of voids to fill.

Manipulation.

Machine mixing is by far the most satisfactory from all standpoints, and mechanical mixers ought to be used wherever possible. If for any good reason their use is impracticable, the following method gives good results:

The gravel or stone should be spread out in a layer on the mixing platform or in a shallow box, covering it with the sand, also in a layer, and afterward with the cement. If this dry mass is cut through from the top to the bottom, a uniform mix will be assured. The mixing should be thorough and the mass should be well turned over at least twice before any water is added.

Water is put in in small quantities, from a hose with a spray or sprinkler attachment, and the mass is manipulated until it is of the desired consistency. This is such that the mass looks and acts like a stiff jelly, but it

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should stand up well after it is tamped into place.

Another method that has many advocates is to spread the sand out first, covering it with the cement, and mix the two until the consistency of the mass is uniform, that is, until the cement is thoroughly distributed through the sand. Then add water in the form of a spray until the mass is plastic. It may now be spread out on the platform or bottom of the box and the coarser aggregate, previously well moistened, added. The mass is then thoroughly turned at least twice, when it is ready to place in the prepared site of the walk.

Water may be added by the pailful or in any other way by means of which it may be conveniently measured; but it is important that it shall not be dashed violently into the mixture.

As a general proposition, it is best not to make up more than a cubic yard of concrete at any one time, in order to secure thorough mixing of the batch. The fresh concrete may be transported to the sidewalk site in wheelbarrows, and a good test of the proper consistency of concrete is that it does not "quake" after it is loaded into the barrow.

Preparation of the Site.

The location of the walk once being determined, the site should be carefully staked off, running the lines such a distance apart

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that the distance between them is 4" wider than it is desired to make the finished walk. All roots of trees and other wood or material liable to decomposition should be carefully removed. So should all large stones, pieces of sod or turf, and other obstructions to a clear excavation. Where soft spots are uncovered in the process of excavation, they should be filled in with solid material, properly tamped to a good bearing surface.

The heaving and throwing of walks, so often attributed to tree roots growing up under the walks, is more often the result of the movement of the earth caused by the swaying of nearby trees. Roots, however, do grow close to the stone, as they find moisture there, and elm and maple roots should be looked after especially, as they are likely to cause the most trouble.

Sub-Base.

No deep excavation for sidewalk foundations is necessary, except in very extraordinary cases. The practice of excavating a trench a foot deep and then filling in 8" or so has been almost universally dispensed with, and with excellent results. It will generally be found satisfactory to remove the sod and top soil to a depth equal to that of the finished walk, as planned. In what little foundation work is done it will be found advisable to tamp in thin layers, thus giving a more solid base for the concrete.

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In the excavation should be placed a foundation of sand and broken stone, or gravel, with the sizes well graded, so that when tamped it presents a hard and uniform surface. Where ashes or cinders are used in this foundation and it is laid so as to be porous, agricultural tile should be laid to drain off any water which might otherwise accumulate and freeze, with resultant damage to the walk.

The foundation should be thoroughly moistened, to the same extent as the fresh concrete, before the latter is laid upon it. This should be dumped in and tamped down to a thickness ranging from 4" to 6", according to location and specifications required. As soon as the bottom coat is tamped, and before it has had time to set, the top coat must be added.

Tools.

Devices of various shapes are on the market for the use of sidewalk workers. These consist of rollers, jointers, groovers, edgers, tampers, trowels, floats, and so on. They are practically essential to securing a neat finish and appearance. Care should be exercised in the selection of tools, for there are some on the market which will not stand the strain of continued use.

Curing and Protection.

As soon as the walk is completed, it should be carefully moistened and kept under cover

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from wind and sun for at least three days. In hot weather the walks should be moistened in the morning and the evening, when the sun is not too hot. This practice prevents the cement from drying out too fast, with resultant weakening and bleaching. General practice recommends the erection of a canvas screen over and around the work, the material being set on a slant, so as to drain rain water off.

If the walk is laid in freezing weather, warmed materials are essential. The water must be at least lukewarm and the sand and gravel or stone free from frost. For protecting the work from injury by cold, different contractors use different means. Paper, sawdust, sand, shavings and even manure are used to cover the work and protect it. Tar paper is also utilized. It is recommended that the covering be permitted to remain on work laid in freezing weather for at least three weeks.

Cost of Walks.

Most books dealing with sidewalk construction say practically nothing of the important subject of costs. This omission is the result of the fact that it is impossible to give cost figures for one locality that are of much benefit in another. In the larger cities, for example, where material has to be hauled a considerable distance, as in the case of sand and gravel, and where the labor costs

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are high, the cost of a concrete sidewalk is necessarily comparatively large. Prices of all kinds of material, from cement to water, vary very widely in different sections of the country and in different communities.

A fairly large canvass of representative contractors and sidewalk men has failed to establish any good average cost. The section of this book which deals with the amounts of material required for sidewalks of various thicknesses will be found helpful in estimating the quantities of each required and the local cost being known the contractor can figure with fair accuracy on what his work will cost him, finished.

Estimating on Work.

One barrel of Portland cement, it is estimated will lay about 60 square feet of walk, 5" thick at the middle and 4" thick at the edges, 6' wide, when mixed in the proportions suggested in foregoing paragraphs. Knowing the cost of sand, gravel and labor, the sidewalk maker can form a fairly good idea of what the walk is going to cost him to lay and what he ought to charge for it in order to make a fair profit. Good walks are the best advertisement, and a neat nameplate set into the surface of the finished walk is an excellent business card. The man who makes a reputation for walks that look well and wear well will have no difficulty in obtaining a fair price for his work.

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Street Crossings.

The foundation for concrete street crossings should be the same as for sidewalks. The base should consist of a layer $4\frac{1}{2}$ " deep, composed of 1 part of Portland cement and 4 parts of clean sand and gravel, thoroughly mixed dry, properly wetted, and tamped to uniform grade. The surface should consist of a layer $1\frac{1}{2}$ " thick, composed of 1 part Portland cement and $1\frac{1}{2}$ parts of good, clean, sharp screened sand, thoroughly mixed when dry and wetted to the consistency of thick mortar. This top surface should be thoroughly troweled into the base and finished to conform with the grade established by the city engineer.

Curbing.

After excavating to a proper depth, set frames for curbing with spreader board between, not less than 4' apart. Brace frames thoroughly opposite these spreading boards, keeping the outside frame at all times in line. Concrete for curbing should be composed of 1 part Portland cement to 5 parts clean, sharp sand and gravel, thoroughly mixed dry and then wet to a proper consistency. After the concrete has been thoroughly mixed, tamp in place, using sheet iron division plates to cut the curbing in sections not less than 4' nor more than 6' in length. The top coat of curbing should be at least $\frac{1}{2}$ " in thickness

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and should consist of 1 part of Portland cement to 2 parts of clean, sharp, screened sand, and should be thoroughly smoothed off with a trowel on the edges and finished to its desired shape with an edger or curb tool.

For business streets, curbing should be from 18" to 22" deep and 5" in thickness at the top and 7" at the bottom. For residences curbing may be 14" or 16" in depth, but of no less thickness than for street curbing.

There has been a great deal of discussion as to whether it is best to put the curbing on a business street outside of the walk or let the walk rest on the curbing. Experience has shown the latter method to be preferable; that is, let the walk rest on the curbing. This allows the walk to slide back and forth on the curb as it expands and contracts without disturbing the curb, while if the curb is placed outside the walk the expansion of the walk may displace it.

Reinforced Sidewalks.

If necessity requires that a sidewalk shall be built in such a location that the supporting soil is likely to be washed from beneath it, reinforcement is an excellent precaution. We have in mind such walks as are sometimes built on sandy soil, in locations liable to attack from unusually high water. If the sidewalk builder will lay a mesh of expanded metal, the width of the walk, and about 2" from the lower level of the bottom coat, he

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will have a construction that will at least support its own weight until such time as the underpinning can be replaced and tamped to a solid bearing surface. A 6" mesh should be ample for all ordinary purposes.

Hints and Suggestions.

Do not attempt to use a mixture of concrete after the set has begun.

Avoid the use of sand that is too fine. If you use it, you will have trouble.

Moisten the coarse aggregate well before adding the cement. It assists the cement in adhering to the particles.

Don't scatter Portland cement on the surface of your finished work. If you do, you will have difficulty at that particular point.

In preparing the excavation for a cement sidewalk, absolute drainage is essential, if trouble from freezing water, with consequent expansion, is to be avoided.

Shade trees should be set not less than 4' from the walk and in the case of trees whose roots run close to the surface of the ground, a distance of 10' is still better.

Union between the top and the bottom coat is best accomplished by tamping them together. Have enough water so that the air in the concrete will escape when the tamping is done.

Be sure that your bottom coat is still moist and fresh when the top coat is applied. Otherwise, the two will not join. Be careful,

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too, that no dust or dirt is lying on the bottom coat, or you will fail to get a bond.

A barrel of cement will give, in the proportions of 1 part of cement, $2\frac{1}{2}$ sand and 5 gravel for the bottom course, and 3 of sand to 5 of cement for the top course, 25 square feet of walk 8" thick and 55 square feet of walk 5" thick.

Some walk-makers sprinkle thoroughly slacked lime that has been finely ground, on the surface of the walk before it has begun to harden. This practice tends to delay the set a little and also produces a good color effect. Lime that has been prepared in this manner, added to the cement used in the top dressing or coat, will whiten the walk and assist in shedding the water.

Finish the walk while the upper surface is still moist and easily worked. Avoid too much use of the trowel. In the action of this tool, a vacuum is created between the surface of the walk and that of the trowel, with the result that particles of neat cement are drawn to the surface, where they dry out and are worn off, with the result that the top coat is robbed of its proper proportion of cement. If the walk is finished after it has begun to set, the resulting surface will be brittle and will crumble easily.

Where broken brick and cinders are used in filling in the excavation, it is wise to tamp them as solidly as possible and to cover them with a layer of sand in order to prevent op-

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posite action in expansion from freezing. One contractor explains the action of frost in cracking walks by saying that the ground expands, owing to the action of the freezing water, while the hardened cement contracts from the cold. The two forces act in direct opposition, so some means should be taken to prevent the sub-soil from freezing to the lower surface of the walk. Careful provision for thorough drainage will avoid this danger.

Albert Moyer, a sidewalk expert, suggests the advisability of making the entire walk a uniform slab of closely compressed, carefully selected stone. Just before the surface dries, he advocates scrubbing it with a wire brush, of the kind used in cleaning boilers. A gentle stream of water played from a hose in the path of the brush will assist in removing the thin skin of neat cement which gives the walk its original neat finish, but which in time wears off under traffic. For walks in which appearance is not the first consideration, this suggestion is an excellent one, as it produces a walk of first-rate wearing qualities.

Cellar Floors.

In laying cellar floors the methods differ somewhat from those employed in sidewalk construction. Owing to the fact that the concrete is not exposed to the action of wind and weather, there is a great deal less expansion and contraction, and in floor work under

shelter, expansion joints are dispensed with, except in very large floors. They are not required in ordinary residence construction.

For ordinary cellar floors, a layer of concrete not less than $1\frac{1}{2}$ " thick, over a 4" bed of cinders, is generally sufficient. The concrete should be mixed in the proportion of 1:3, with bank-run sand and gravel, and floated to a level.

Drainage is an important point to consider in cellar work, and where floors are to be laid on clay, sub-drainage, with tile or otherwise, should be provided.

Repairing Plank Walks.

It often becomes necessary under a city ordinance to build a new wooden walk when the old plank are perfectly good, on account of the stringers being too rotten to hold a nail. This expense can be avoided by putting in a concrete stringer without disturbing the plank. To do this, dig a small trench under each side of the walk, extending about 4" under and about 4" deep; drive spikes into the plank about 2" from the edge of the walk, so as to extend down into the trench. Then fill the trench with concrete, tamping it up to the plank. If the plank are warped up at the end, weight them down until the nails are firmly set in the concrete stringer. This will insure you a foundation that will outwear your plank. Should there be any holes in the walk, cut out the rotten wood, fill in the

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cavity (if more than 3" deep) with cinders well tamped; then fill with concrete to the surface. At a very small cost, an old walk may in this way be kept in repair for years.

Concrete Floor Over Wood Floor.

Many times it is desired to replace an old wood floor with one of concrete. This can be done by laying the new floor over the old. In preparing for this, examine all the joists well, nail down all loose boards, and during the construction and curing of the work, shore up all weak spots that may manifest themselves. Lay on the floor expanded metal or heavy wire cloth of not over six-inch mesh, tying down the ends with light wire staples. The strips should overlap one another about three inches. Wet the floor thoroughly.

Upon this, lay a course of concrete about $1\frac{1}{2}$ " thick, except on driveways, where it should be $2\frac{1}{2}$ " thick. Lay the floor in 4' strips, returning after each operation and finishing that strip with a wooden float after leveling with a straight-edge. Repeat this operation the entire length of the floor. Be careful not to fracture the floor after the process of crystallization has started. This accident is likely to be caused by the springing action of some of the boards adjacent to the newly-laid concrete.

The mixture should be 1 part Portland cement to 3 parts bank-run sand and gravel,

to be laid in one continuous layer. Gutters may be formed where necessary. This process will be found valuable in repairing old barn floors and has been used with great success in any number of instances.

Forms and Dividing Plates.

Recognition of the necessity of providing some certain means to secure definite joints as a protection against possible damage due to expansion and contraction, early led to the invention and marketing of dividing plates. These originally took the form of slotted metal strips, about $\frac{1}{8}$ " thick, the slots being so arranged as to engage the edges of the 2x4's formerly used at the sides of the walks. Their use became so popular that other and more nearly complete metal form systems were placed on the market. Today there are several ingenious devices in metal which require to be held with long steel pins only, in order to provide a rigid, accurate and durable means for confining the concrete entering into the construction of the sidewalk. Flexible strips provide for curves of any desired radius and means for making the form and dividing plates a single unit have been invented. The old wooden strips are properly becoming less common. With anything like reasonable care, the metal forms last a long time, and their use results not only in better work but actually in lowered expense for construction.

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In use, the forms and strips are oiled or in some other manner prepared so that the green cement will not adhere to them when it has set. As soon as the concrete has begun to harden, the forms and plates are raised and the completed walk is left, with clean, smooth edges and definite expansion joints, going through both the top and the bottom coat of the walk, down to the foundation.

What has been said in regard to sidewalk construction applies with equal force to the construction of other pavements for similar purposes — station platforms, hall-ways, floors in buildings and basements and so on. The American farmer, ever alert to take up the new thing of value, has laid thousands of square feet of feeding floors for his stock, within a comparatively short time.

Where sidewalks are of necessity pierced by iron pipes, manholes, posts or other metal members, expansion joints, with a thickness of at least $\frac{1}{8}$ ", should be provided.

In providing drainage underneath sidewalks, a fall of at least $\frac{1}{4}$ " to every running foot should be provided. It cannot be emphasized too strongly that the accumulation of water underneath a sidewalk opens the way for damage. When the water freezes, the ice expands. Concrete, on the other hand, contracts in the cold, and the resultant opposed forces are bound to result in serious trouble.

Be careful to see that your foundation of cinders, broken brick or what not, when, for

any good reason, one is provided, is thoroughly soaked with water before the concrete for the lower coat is placed. If this precaution is not taken, it is certain that the porous material, absorbing a considerable quantity of water, will rob the lower coat concrete of much of the moisture it needs for proper crystallization and curing.

For floors to be used in slaughter-houses, where a non-absorbent quality is, of course, a necessity, Albert Moyer, a well known authority, suggests the use of concrete mixed with oil. Owing to the alkaline qualities of the cement, when it is mixed with water and with oil an emulsion is formed, with the result that the cement, oil and water are thoroughly incorporated in the concrete. From 10 per cent to 15 per cent of non-volatile mineral oil is used, the oil being thin enough to pour readily. Mineral oil of this character weighs from $7\frac{1}{2}$ to 8 pounds per gallon.

In practice, the oil in the percentage named is added just after the water and the mixing proceeds as usual. The same amount of careful mixing is necessary when oil is used as when it is omitted. The use of oil slightly delays the final set of concrete, but not to a very great extent.

Color for Sidewalks.

The following table of colors is suggested for a 1:2 mortar, used as the top dressing of a sidewalk. The quantities shown are those

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required for each 95 pounds (1 bag) of Portland cement utilized.

Color.	Material.	Quantity.
Black.....	Excelsior Carbon Black...	2 lbs.
Black.....	Manganese Dioxide	10 lbs.
Buff.....	Yellow Ochre	4 lbs.
Blue.....	Ultramarine or Azure Blue.	4 lbs.
Gray.....	Lamp Black (Bone Black).	½ lb.
Green.....	Ultramarine	7 lbs.
Green.....	Oxide of Chromium.....	7 lbs.
Brown.....	Roasted Iron Oxide.....	6 lbs.
Red.....	Raw Iron Oxide	6 lbs. to 10 lbs.
Bright Red....	Pompeian Red	6 lbs.
Yellow.....	Ochre	6 lbs.

These colors should be mixed thoroughly with the sand or screenings used.

To be at all satisfactory, colors must obviously be permanent in character. Mineral colors are the only ones that answer this requirement, and care should be taken in their purchase. There are several reputable dealers in material especially designed for use in concrete work.

Shop-Made Sidewalks.

In the manufacture of concrete, as in anything else, a constant product results only from constant conditions. Two batches of concrete made under exactly the same conditions must obviously be identical in character. The nearest approach to constant conditions obtains in a factory, where the product is made of selected, inspected material, using the same quantities of each, under careful inspection. Where methods of manu-

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facture, including the important item of curing, are constant, good concrete results. These facts have suggested the advantages of concrete sidewalks laid as flagstone walks used to be laid. The preparation of the foundation bed and the provision of a cushion of sand are, of course, the same for concrete slabs as they were for the old stone walks. Slabs of the desired dimensions, plain or reinforced, are readily made in a concrete products plant and kept in stock for use as required. Within certain reasonably close limits, slabs for reinforced sidewalks and for floors are alike. Their manufacture offers attractive possibilities to the man who has a proper plant for the manufacture of concrete products.

For the best results, concrete should not be thrown with a shovel a distance of more than 4', nor should it be dropped through a greater distance. In traversing greater distances, the particles of aggregate become separated, and instead of remaining a homogeneous mixture, all the larger particles of gravel or stone are found at the bottom.

A popular method of figuring labor costs is to estimate that six men will finish about 700 square feet of concrete walk in a day, where the work has a thickness of 4". The gang in this case would consist of five laborers and one finisher. This is simply an empirical method of estimating. The only safe way to arrive at costs is to keep your own

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cost data on each job, with full notation of conditions. In a comparatively short time, you will have valuable material for estimating other work of the same character.

Experts of the Atlas Portland Cement Co. suggest the following tables of quantities required, which will be found very useful in computing costs for sidewalk construction:

MATERIALS FOR 100 SQ. FEET OF CONCRETE.

Bags of Cement to 100 Sq. Feet of Concrete Surface.				Bags of Cement to 100 Sq. Feet of Mortar Surface.			
Thickness Inches	Proportions			Thickness Inches	Proportions		
	1:1½:3	1:2:4	1:3:6		1:1	1:1½	1:2
3	8½	6½	4¾	½	3½	2¾	2¼
4	11	8¾	6	¾	5	4	3½
5	14½	11	7½	1	7	5¼	4½
6	16¾	13¼	9½	1¼	8¼	6½	5¾
8	22¾	18	12	1½	10	8	6¾
10	28¾	21½	15½	1¾	12	9¼	7¾
12	34¾	25½	18½	2	14	11	9

SURFACES LAID WITH ONE BARREL OF CEMENT.

No. of Sq. Ft. of Concrete (Base) Laid with 4 Bags (1 Bbl.) of Cement.				No. of Sq. Ft. of Mortar Surface Laid with 4 Bags (1 Bbl.) of Cement.			
Thickness Inches	Proportions			Thickness Inches	Proportions		
	1:1½:3	1:2:4	1:3:6		1:1	1:1½	1:2
3	47	60	83	½	114	146	178
4	36	46	66	¾	80	100	114
5	27	36	52	1	57	73	89
6	24	30	41	1¼	48	60	70
8	17	22	33	1½	40	50	59
10	14	19	26	1¾	33	43	52
12	12	15	21	2	29	36	44

Note.—Four bags of cement equal 1 barrel.

For proportions 1:1½:3 use for every 33 bags of cement 1 large double load of sand and 2 of gravel.

For proportions 1:2:4 use for every 23 bags of cement 1 large double load of sand and 2 of gravel.

For proportions 1:3:6 use for every 15 bags of cement 1 large double load of sand and 2 of gravel.

One large double load contains 40 cubic feet, or 1½ cubic yards.

No material used in the top dressing should be utilized if more than 30 minutes have elapsed from the time of its being

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mixed. If the concrete has not hardened, however, it may be used in the base.

For the man who wants to build sidewalks as a business, that is, the concrete sidewalk contractor, the patented forms of metal, now on the market are practically essential. For the farmer, however, or for the man who wants to lay a small sidewalk for himself, the following suggestions, taken from the sidewalk specifications of the Universal Portland Cement Co., Chicago, Ill., are of value:

Equipment for mixing concrete should be a tight platform about 7' x 12', square-pointed shovels, a mortar hoe, steel-body wheelbarrow, sand screen, mortar box, water barrels, buckets and a measuring box, holding 4 cubic feet.

A well-made platform for mixing concrete should be part of the regular equipment of a farm, and it will be cheaper to build a good one at the outset than to waste time and money in constructing and using temporary ones. Such a platform as is suggested can be built of 2" lumber nailed upon three 2" x 4" stringers, rounded on the ends. The outside stringers should project a little beyond the edges of the platform and be bored for clevis irons, so that the platform may be dragged about the farm by a team. The rounded ends of all the stringers will facilitate transportation.

To make the platform there are required:

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12 pieces 2" x 12" x 7', dressed on one side and two edges.

2 pieces 2" x 2" x 12', dressed on one side and two edges.

2 pieces 4" x 4" x 13', rough.

1 piece 4" x 4" x 12', rough.

Dressed lumber will provide a smooth and tight platform, with resultant decrease of labor in shoveling. Care must of course be taken to have the lumber free from warp, in order to make tight joints between the planks.

Methods of mixing concrete on a platform have already been suggested under "Hand Mixing." (Which see.)

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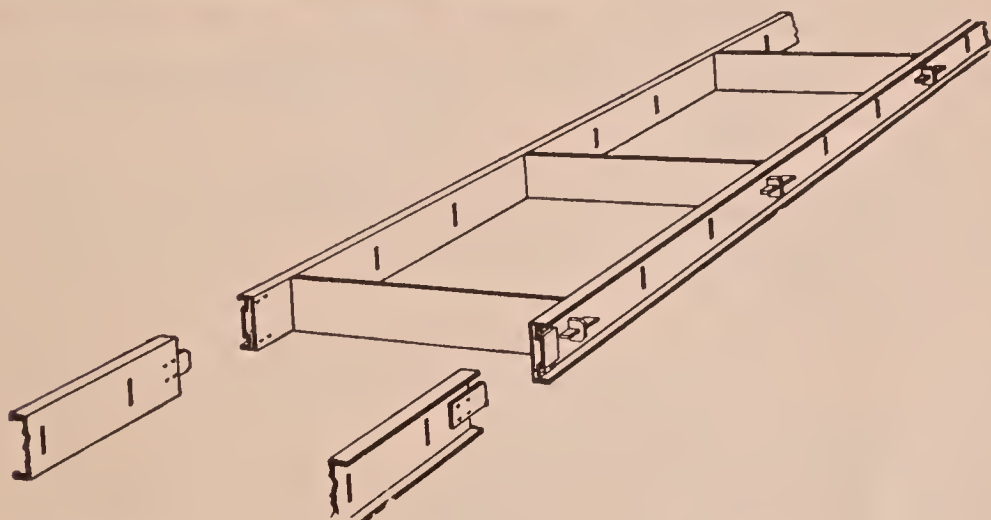
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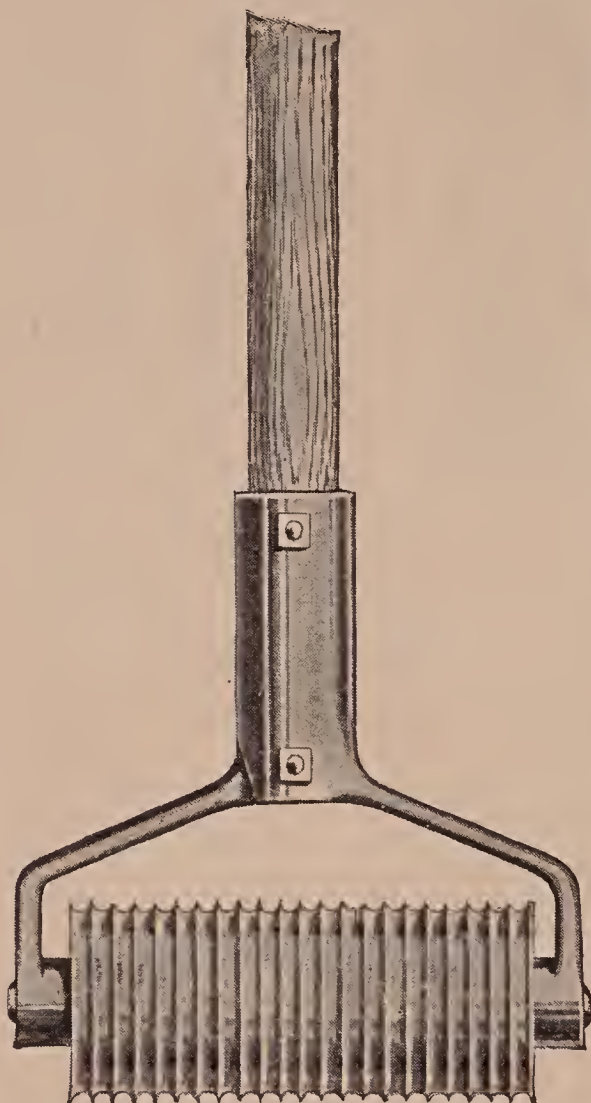
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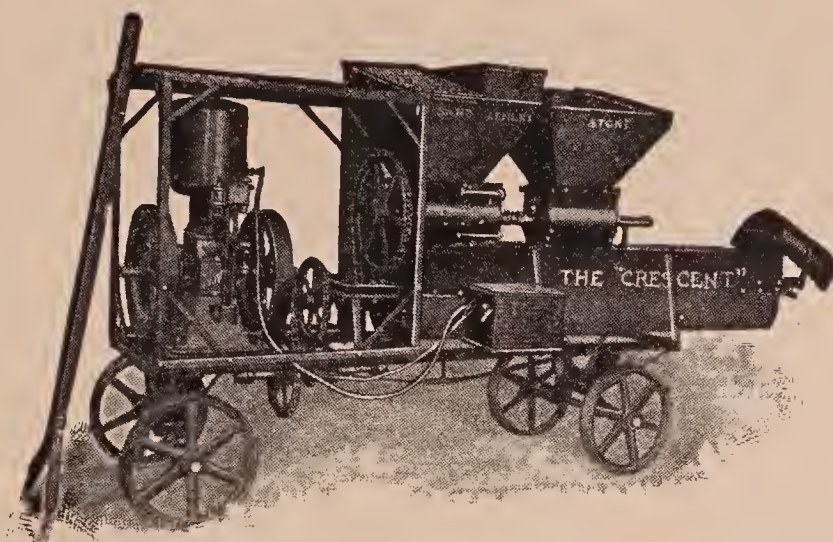
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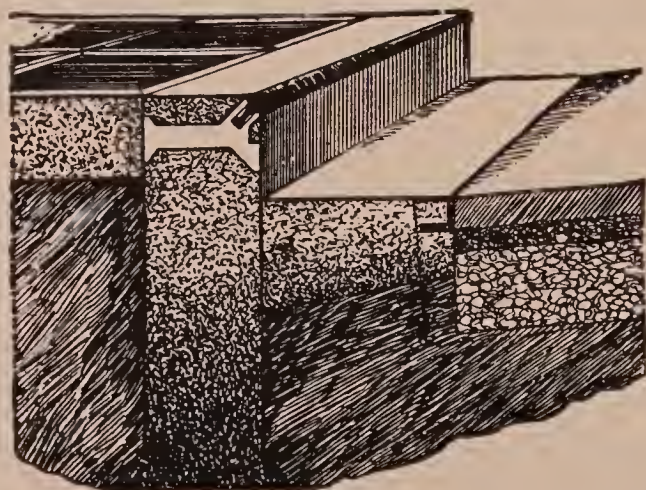
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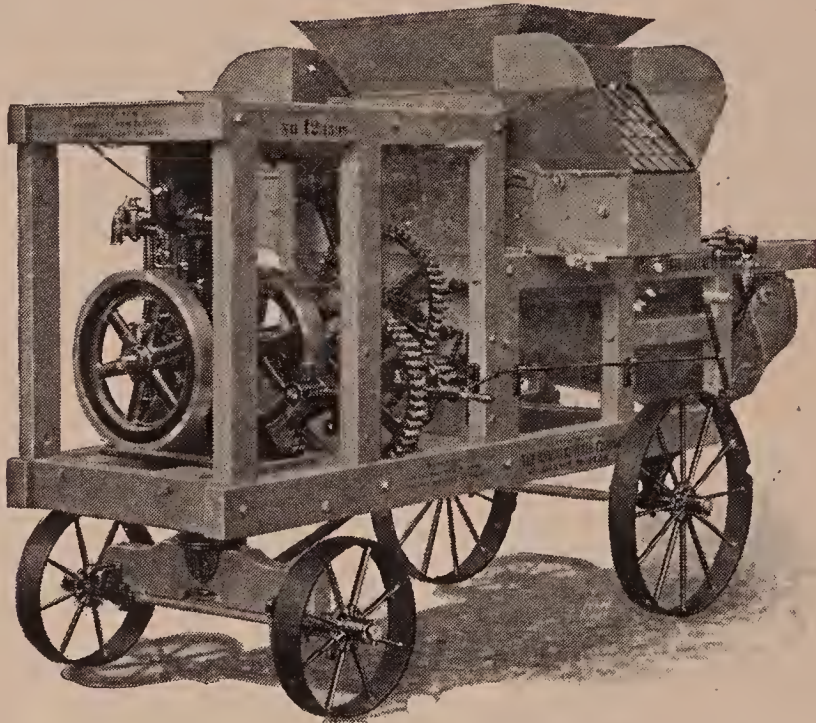
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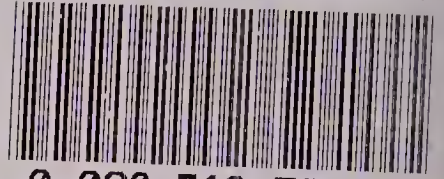
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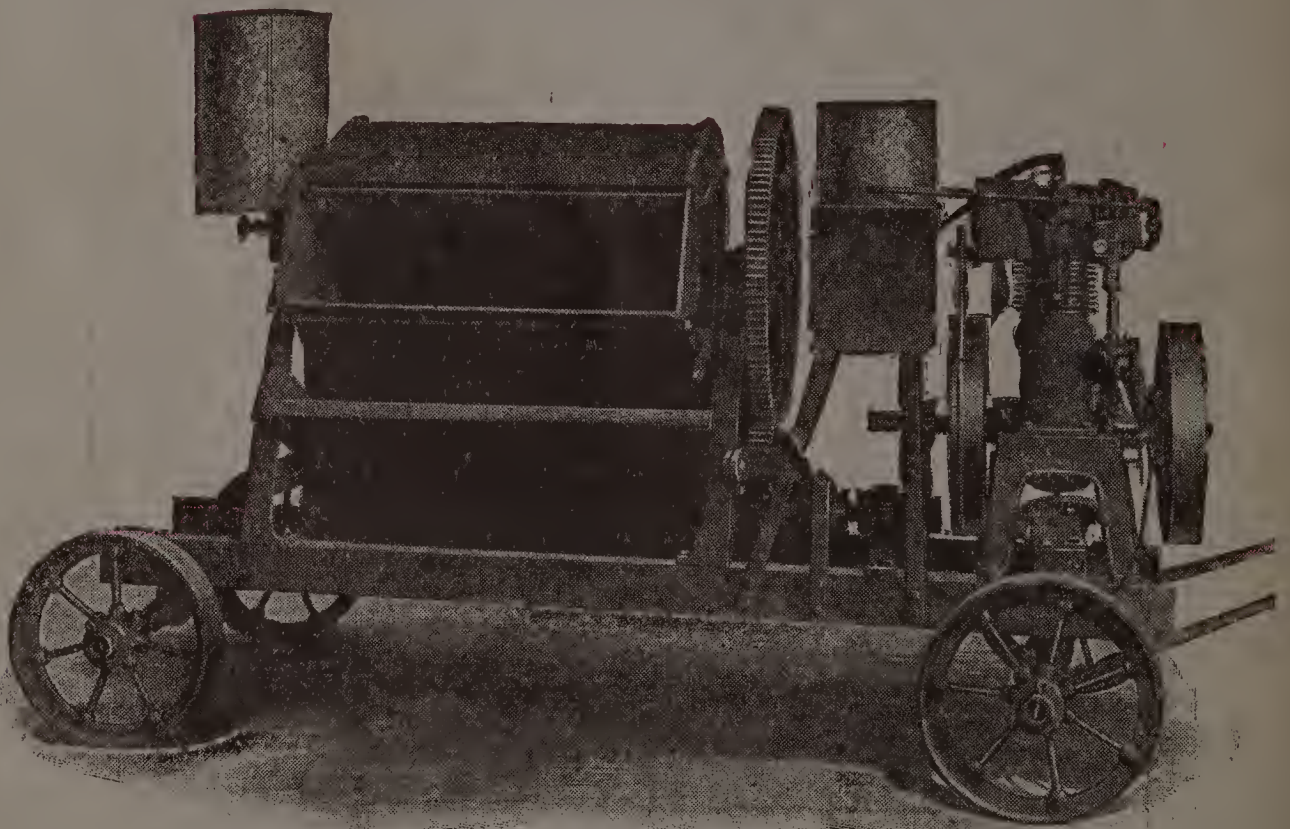


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